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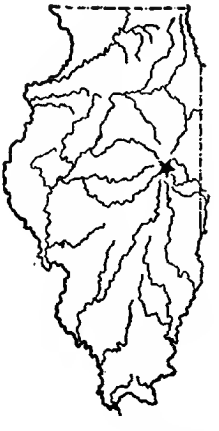
A STUDY OF THE RATE AND ECONOMY OF GAINS OF FATTENING STEERS

WITH SPECIAL REFERENCE TO THE INFLUENCE OF THE AMOUNT AND THE CHARACTER OF FEED CONSUMED

By H. W. MUMFORD, H. S. GRINDLEY,
A. D. EMMETT, AND SLEETER BULL



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Contents of Bulletin No. 197

A STUDY OF THE RATE AND ECONOMY OF GAINS OF FATTENING STEERS

WITH SPECIAL REFERENCE TO THE INFLUENCE OF THE AMOUNT AND THE CHARACTER OF FEED CONSUMED

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This bulletin is one of a series reporting the findings of an investigation in regard to the effect of variations in the amount and character of feed consumed upon the nutrition of two-year-old steers. It gives the results relating to the effect upon the rate and economy of gains: (1) of variations in the amount of feed consumed ranging from maintenance to full feed rations; (2) of variations in the proportions of roughage and concentrates in the ration; and (3) of the substitution of a nitrogenous concentrate for a part of the grain of a ration of clover hay and ground corn in the ratio of 1 to 5.

THE EXPERIMENT

The Animals.—The animals used were sixteen two-year-old high-grade Hereford steers grading as choice feeders and weighing from 750 to 1,000 pounds. These animals were selected from the same herd and were similar in breeding. From birth to the time of purchase they had been treated very much alike. During a period of about two months preliminary to the experiment, they were kept in paved lots with access to open sheds. During the experiment proper, which began May 27, 1908, and ended February 10, 1909, a period of thirty-seven weeks, eight of the steers were kept in ordinary stalls on concrete floors, well bedded with pine shavings. The other eight steers were kept in digestion and metabolism stalls, and the digestibility of their rations was determined during the thirty-seven weeks of the experiment.[2] Each steer was weighed daily at 2 p. m.

Rations and Feeds.—During the first month of the period preliminary to the experiment the ration consisted of corn silage, clover hay,

[1]The authors take pleasure in acknowledging their great indebtedness to Professors L. D. Hall and H. O. Allison for their generous and helpful cooperation and assistance in the planning and conducting of this investigation.

[2]Ill. Agr. Exp. Sta. Bul. 172 (1914).

and alfalfa hay. At the beginning of the second month ground corn was added to the ration, and the feeding of alfalfa was discontinued. Four days later the feeding of corn silage was discontinued. During the first twenty-two weeks of the experiment proper the ration consisted of clover hay and ground corn, and during the last fifteen weeks of clover hay, ground corn, and linseed oil meal. Half an ounce of salt, given daily, was taken very consistently by all of the steers. Water also was given twice daily, and an exact record was kept of the amounts drunk.

The steers were fed twice daily, the rations for each feeding being weighed out a week in advance. The refused feed, or "orts," was collected every day and the amount deducted in computing the amount of feed consumed.

To determine the effect of variations in the amount of feed consumed, the sixteen steers were divided into four lots of four animals each, and each lot was given thruout the experiment an amount of feed different from that received by the other lots. One was given just enough feed to maintain the weights of the steers about constant; another, as much as the steers would eat readily; another, an amount of feed equal to the maintenance ration plus one-third of the difference between the maintenance and the full-feed rations; and another, an amount equal to the maintenance ration plus two-thirds of the difference between the maintenance and the full-feed rations. In this bulletin the first of the above-described lots has been designated as the "maintenance" lot; the second, as the "full-feed" lot; the third, as the "one-third-feed" lot; and the fourth, as the "two-thirds-feed" lot. Beginning with the 31st week, two steers each from the maintenance, the one-third-, and the two-thirds-feed lots were gradually put on a full-feed ration and continued thus until the end of the experiment. The lots were as similar as possible in regard to age, condition, and breeding of the animals. However, there was some difference in the initial weights of the lots, as shown in Table 12, page 586.

To determine the effect of variations in the proportions of roughage to concentrates in the ration upon the rate and efficiency of gains, and the effect of the introduction of linseed oil meal into the ration, the experiment was divided into five experimental periods. During the first experimental period the ration consisted of clover hay and ground corn in equal amounts; during the second, of one part of clover hay and three parts of ground corn; during the third, of one part of clover hay and five parts of ground corn; and during the fourth and fifth, of one part of clover hay, four parts of ground corn, and one part of linseed oil meal. Thus the proportion of concentrates was gradually increased up to the third experimental period, and then maintained constant to the end of the experiment. These changes in the ration made from one experimental period to another were effected

very gradually in transitional periods. The first and third transitional periods were each two weeks in length; and the second and fourth, three weeks each in length. Table 1 gives the division of the experiment into periods and the proportion of roughage to concentrates fed in each.

TABLE 1.—DIVISION OF EXPERIMENT INTO PERIODS, AND RATIOS OF HAY, CORN, AND LINSEED MEAL IN RATIONS

Experimental period	Experimental weeks	Number of weeks in period	Ratio of hay to corn to linseed meal
1	1–5	5	1:1:0
2	8–13	6	1:3:0
3	17–22	6	1:5:0
4	25–30	6	1:4:1
5	34–37	4	1:4:1

As previously stated, the digestibility of the rations of two steers of each lot was determined continuously for the thirty-seven weeks of the experiment. A detailed description of the equipment, the methods of weighing, sampling, and analyzing the feeds, and the collection, sampling, and analyzing of the refused feed and feces are given in Bulletin 172 of this station.

AMOUNTS OF FEEDS CONSUMED

The amounts of feeds consumed by each steer per period are given in Table 2. The average amounts of feeds consumed daily by each steer are given in Table 3. The average weights of feeds consumed daily per lot are given in Table 4.

As previously noted, the refused feed, or orts, from the last feeding was cleaned out before each feeding and weighed. It was assumed that the feeds were present in the orts in the same proportions as in the ration. Accordingly, the amount of each feed refused was calculated from these data. Altho this is not strictly accurate, yet, inasmuch as the amount of orts was usually small, only a slight error was thus introduced. The amount of each feed refused, subtracted from the amount of that feed offered, gave the amount of each feed actually consumed.

Maintenance Lot.—While it was planned originally to give the maintenance steers just enough feed to keep their weights practically constant, yet for various reasons this plan was not strictly followed and the animals of this lot made considerable gain during Periods 1, 4, and 5, altho they were practically on a maintenance ration during Periods 2 and 3. During the first period of the experiment (weeks 1–5), the ration consisted of 5.5 pounds of ground corn and the same amount of hay per day. The amount of corn was increased gradually

while the hay was decreased during the first transitional period (weeks 6–7), so that during the second experimental period (weeks 8–13) the steers received an average of 2.2 pounds of hay and 6.6 pounds of corn per head per day. During the second transitional period (weeks 14–16) the amount of hay was reduced still further while the corn was increased, so that during the third experimental period (weeks 17–22) the steers received an average of 1.4 pounds of hay and 6.8 pounds of corn per day per head. During the third transitional period (weeks 23–24) old-process linseed meal was gradually substituted for an equal amount of corn in the ration. During the fourth experimental period (weeks 25–30) the steers consumed 1.4 pounds of hay, the same amount of linseed meal, and 5.4 pounds of corn per head daily. In the fourth transitional period (weeks 31–33) Steers 653 and 650 were gradually placed upon a full-feed ration, so that during the fifth test period (weeks 34–37) they consumed 2.9 pounds of hay, the same amount of linseed meal, and 11.7 pounds of corn per head daily. Steers 656 and 658 which were continued on maintenance consumed 1.3 pounds of hay, the same amount of linseed meal, and 5.3 pounds of corn during this period.

One-Third-Feed Lot.—The steers of this lot were started on 7.9 pounds of ground corn per day per head and the same amount of hay. During the first transitional period the hay was decreased and the corn increased, so that during the second experimental period they consumed an average of 3.7 pounds of hay and 11.2 pounds of corn per head daily. During the second transitional period the hay was decreased still further and the corn was increased, so that during the third period the steers consumed an average of 2.2 pounds of hay and 11.1 pounds of corn daily. In the third transitional period linseed meal was substituted for some of the corn in the ration, so that during the fourth experimental period the steers consumed an average of 2.1 pounds of hay, 8.5 pounds of corn, and 2.1 pounds of linseed meal per head daily. In the fourth transitional period the rations of Steers 667 and 666 were gradually increased to full feed, so that during Period 5 they consumed 3.2 pounds of hay, the same amount of linseed meal and 12.7 pounds of corn per head daily. Steers 669 and 662 consumed 2.2 pounds of hay, the same amount of linseed meal, and 8.7 pounds of corn in this period.

Two-Thirds-Feed Lot.—The steers of this lot consumed an average of 10.3 pounds of hay and the same amount of corn per head daily during the first experimental period. During the first transitional period the hay was decreased and the corn increased, so that during the second experimental period the steers consumed an average of 5.3 pounds of hay and 15.8 pounds of corn per head daily. During the second transitional period the proportion of corn to hay was increased still further, so that during the third experimental period the steers

consumed an average of 3.1 pounds of hay and 15.5 pounds of corn per head daily. As was the case in the other lots, some of the corn was replaced by linseed meal during the third transitional period, so that during the fourth experimental period the steers consumed an average of 2.9 pounds of hay, 11.5 pounds of corn, and 2.9 pounds of linseed meal per head daily. During the fourth transitional period Steers 668 and 652 were gradually placed upon a full-feed ration, so that during Period 5, Steer 668 consumed 3.5 pounds of hay, 13.9 pounds of corn, and 3.5 pounds of linseed meal. Steer 652 went off feed and was removed at the end of the 34th week. Steers 665 and 657 in this period consumed 3.0 pounds of hay, 12.1 pounds of corn, and 3.0 pounds of linseed meal.

Full-Feed Lot.—During the first experimental period the steers of the full-feed lot consumed an average of 12.1 pounds of hay and the same amount of corn per head daily. As in the other lots, their hay was decreased and their corn was increased during the first transitional period, so that during the second experimental period they consumed an average of 6.4 pounds of hay and 19.4 pounds of corn per head daily. During the second transitional period the proportion of hay in the ration was decreased, so that during the third experimental period the steers consumed an average of 3.5 pounds of hay and 17.6 pounds of corn per head daily. It will be noted that not only less roughage but also less grain was consumed in Period 3 than in Period 2. We are unable to explain why the steers did not eat more at this time, as they were given all the feed they would consume. The effect of this apparent slump in the appetites of the full-feed steers was transmitted to the one-third- and two-thirds-feed lots, as their rations were based upon the feed consumption of the maintenance and full-feed steers as already explained. During the third transitional period linseed meal was introduced into the ration and the amount of corn was decreased, so that during the fourth experimental period the steers consumed an average of 3.5 pounds of hay, 14.2 pounds of corn, and 3.5 pounds of linseed meal per head daily. Steers 663 and 659 went off feed so badly that Steer 663 was removed at the end of the 30th week and Steer 659 at the end of the 33d week.

As a matter of fact, the amounts and proportions of the feeds offered the full-feed lot were not far different from what would have been offered them in a practical feeding operation conducted under the same conditions, altho in most instances the consumption of concentrates in the latter part of the fattening period would have been greater in practical feeding operations.

TABLE 2.—FEEDS CONSUMED BY EACH STEER
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal
Maintenance Lot														
			Steer 653			Steer 650			Steer 656			Steer 658		
1	1–5	1:1:0	189.0	189.0	....	192.6	192.6	....	192.6	192.6	....	192.6	192.6	....
2	8–13	1:3:0	87.1	261.4	....	95.8	287.3	....	95.6	286.8	....	93.9	281.8	....
3	17–22	1:5:0	52.9	264.6	....	58.8	294.0	....	58.8	294.0	....	57.1	285.6	....
4	25–30	1:4:1	54.0	216.2	54.0	58.2	233.0	58.2	58.2	233.0	58.2	56.8	227.4	56.8
5[4]	34–37	1:4:1	81.7	326.9	81.7	81.7	326.9	81.7	37.0	147.8	37.0	37.0	147.8	37.0
Total[5]	1–37	.....	596.4	1690.0	179.3	637.4	1791.6	184.7	577.4	1589.5	133.3	571.9	1568.3	132.8
One-Third-Feed Lot														
			Steer 667			Steer 666			Steer 669			Steer 662		
1	1–5	1:1:0	276.3	276.3	....	270.0	270.0	....	277.9	277.9	....	278.8	278.8	....
2	8–13	1:3:0	153.1	459.2	....	153.4	460.3	....	160.0	479.8	....	161.9	485.4	....
3	17–22	1:5:0	90.1	449.8	....	88.5	442.4	....	96.0	480.2	....	99.0	495.4	....
4	25–30	1:4:1	89.3	357.3	89.3	84.0	336.0	84.0	90.7	362.9	90.7	93.8	375.2	93.8
5[4]	34–37	1:4:1	88.9	355.5	88.9	88.6	354.4	88.6	60.5	241.9	60.5	61.2	244.8	61.2
Total[5]	1–37	.....	912.6	2606.8	246.3	890.7	2537.3	236.3	901.8	2549.9	214.3	915.2	2598.2	219.7
Two-Thirds-Feed Lot														
			Steer 668			Steer 652[4]			Steer 665			Steer 657		
1	1–5	1:1:0	363.5	363.5	....	348.9	348.9	....	362.8	362.8	....	364.9	364.9	....
2	8–13	1:3:0	219.5	658.5	....	210.1	630.4	....	224.7	674.3	....	229.6	689.0	....
3	17–22	1:5:0	126.8	634.1	....	119.3	596.4	....	134.4	672.0	....	141.7	708.0	....
4	25–30	1:4:1	124.9	499.5	124.9	109.8	439.0	109.8	123.2	492.8	123.2	124.0	496.0	124.0
5[4]	34–37	1:4:1	97.5	389.9	97.5	21.5	86.1	21.5	84.0	336.0	84.0	85.4	341.8	85.4
Total[5]	1–37	.....	1227.9	3521.4	313.9	1079.6	2981.3	211.1	1221.7	3503.1	294.4	1253.1	3618.3	300.7
Full-Feed Lot														
			Steer 659[3]			Steer 663[3]			Steer 661			Steer 664		
1	1–5	1:1:0	448.0	448.0	....	408.4	408.4	....	444.1	444.1	....	447.5	447.5	....
2	8–13	1:3:0	260.5	784.9	....	241.3	723.9	....	283.6	851.0	....	297.3	892.0	....
3	17–22	1:5:0	152.7	762.6	....	128.5	642.6	....	144.8	724.2	....	166.0	830.2	....
4	25–30	1:4:1	157.9	631.5	157.9	118.2	472.8	118.2	155.7	622.7	155.7	164.3	657.4	164.3
5	34–37	1:4:1	....	....	....	....	....	....	105.2	420.8	105.2	105.7	422.9	105.7
Total[5]	1–37	.....	1380.2	3808.4	261.1	1144.1	3002.2	145.2	1496.6	4252.3	372.3	1570.3	4543.0	384.1

[1]Removed at end of 34th week. [2]Removed at end of 33d week. [3]Removed at end of 30th week.
[4]Same as full feed in this period. [5]Includes feeds for transitional periods.

TABLE 3.—AVERAGE DAILY FEED CONSUMPTION OF EACH STEER
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal
Maintenance Lot			Steer 653			Steer 650			Steer 656			Steer 658		
1	1–5	1:1:0	5.40	5.40	....	5.50	5.50	....	5.50	5.50	....	5.50	5.50	....
2	8–13	1:3:0	2.07	6.22	....	2.28	6.84	....	2.28	6.83	....	2.24	6.71	....
3	17–22	1:5:0	1.26	6.30	....	1.40	7.00	....	1.40	7.00	....	1.36	6.80	....
4	25–30	1:4:1	1.29	5.15	1.29	1.39	5.55	1.39	1.39	5.55	1.39	1.36	5.41	1.36
5[4]	34–37	1:4:1	2.92	11.67	2.92	2.92	11.67	2.92	1.32	5.28	1.32	1.32	5.28	1.32
One-Third-Feed Lot			Steer 667			Steer 666			Steer 669			Steer 662		
1	1–5	1:1:0	7.89	7.89	....	7.71	7.71	....	7.94	7.94	....	7.97	7.97	....
2	8–13	1:3:0	3.64	10.93	....	3.65	10.96	....	3.81	11.42	....	3.85	11.56	....
3	17–22	1:5:0	2.15	10.71	....	2.11	10.53	....	2.29	11.43	....	2.36	11.79	....
4	25–30	1:4:1	2.13	8.51	2.13	2.00	8.00	2.00	2.16	8.64	2.16	2.23	8.93	2.23
5[4]	34–37	1:4:1	3.17	12.70	3.17	3.16	12.66	3.16	2.16	8.64	2.16	2.19	8.74	2.19
Two-Thirds-Feed Lot			Steer 668			Steer 652[1]			Steer 665			Steer 657		
1	1–5	1:1:0	10.39	10.39	....	9.97	9.97	....	10.37	10.37	....	10.43	10.43	....
2	8–13	1:3:0	5.23	15.68	....	5.00	15.01	....	5.35	16.06	....	5.47	16.41	....
3	17–22	1:5:0	3.02	15.10	....	2.84	14.20	....	3.20	16.00	....	3.37	16.86	....
4	25–30	1:4:1	2.97	11.89	2.97	2.61	10.45	2.61	2.93	11.73	2.93	2.95	11.81	2.95
5[4]	34–37	1:4:1	3.48	13.93	3.48	3.07	12.29	3.07	3.00	12.00	3.00	3.05	12.21	3.05
Full-Feed Lot			Steer 659[2]			Steer 663[3]			Steer 661			Steer 664		
1	1–5	1:1:0	12.80	12.80	....	11.67	11.67	....	12.69	12.69	....	12.78	12.78	....
2	8–13	1:3:0	6.20	18.69	....	5.75	17.24	....	6.75	20.26	....	7.08	21.24	....
3	17–22	1:5:0	3.64	18.16	....	3.06	15.30	....	3.45	17.24	....	3.95	19.77	....
4	25–30	1:4:1	3.76	15.04	3.76	2.81	11.26	2.81	3.71	14.83	3.71	3.91	15.65	3.91
5	34–37	1:4:1	....	....	....	....	....	....	3.76	15.03	3.76	3.78	15.10	3.78

[1]Removed at end of 34th week. [2]Removed at end of 33d week. [3]Removed at end of 30th week.
[4]Steers 653, 650, 667, 666, 668, and 652 were on full feed in this period.

TABLE 4.—AVERAGE DAILY FEED CONSUMPTION OF EACH LOT
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot[1]			One-Third-Feed Lot[1]			Two-Thirds-Feed Lot[1]			Full-Feed Lot		
			Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal
1	1–5	1:1:0	5.48	5.48	...	7.88	7.88	...	10.29	10.29	...	12.13	12.13	...
2	8–13	1:3:0	2.22	6.65	...	3.74	11.22	...	5.26	15.79	...	6.45	19.36	...
3	17–22	1:5:0	1.36	6.78	...	2.23	11.12	...	3.11	15.54	...	3.53	17.62	...
4	25–30	1:4:1	1.36	5.41	1.36	2.13	8.52	2.13	2.86	11.47	2.86	3.55	14.19	3.55
5	34–37	1:4:1	1.32	5.28	1.32	2.17	8.69	2.17	3.02	12.10	3.02	3.77	15.07	3.77

[1]Average of two steers in Period 5, as Steers 653, 650, 667, 666, 668, and 652 were on full feed in this period. The data pertaining to the feed consumption of these steers in Period 5 are given in Table 3.

TOTAL DRY SUBSTANCE CONSUMED

Inasmuch as all the feeds were analyzed chemically every week, data are available from which the consumption of total dry substance may be calculated. These results, calculated on the basis of 1000 pounds live weight, are given in Table 5. An inspection of this table shows that altho there was considerable variation in the consumption of dry substance by the steers of the same lot, yet the differences between lots were much greater than the individual differences within the lots.

It is of interest to compare the consumption of dry substance with the amounts prescribed by the Wolff-Lehmann feeding standard[1] for maintenance and fattening of cattle. For maintenance, these feeding standards call for 18 pounds of dry substance per 1000 pounds live weight daily. The average consumption of dry substance by the four maintenance steers of this experiment varied from 8.0 pounds to 11.3 pounds, or approximately from one-half to two-thirds of the amount prescribed by the standard. During Periods 2 and 3, when the steers were practically on maintenance, the consumption of dry substance was 8 to 9 pounds.

The Wolff-Lehmann feeding standard recommends from 26 to 30 pounds of dry substance for a 1000-pound fattening steer. The steers of the full-feed lot consumed on the average from 13.4 to 22.1 pounds of dry substance, or approximately one-half to two-thirds of the amounts prescribed in the standards. From this it seems safe to conclude that the Wolff-Lehmann standards for dry substance are unnecessarily high in the cases of maintenance and fattening cattle. Of course, if large amounts of less digestible feeds, such as the roughages, are used they are more nearly correct, but even then they remain too high.

Henry and Morrison[2] have recently published modifications of the Wolff-Lehmann standards for maintenance of cattle and for fattening of two-year-old steers. They recommend 13 to 21 pounds of dry substance for maintenance, as compared with the amounts used in this experiment, 8.0 to 11.3 pounds. For fattening two-year-old steers on full feed they recommend the following amounts of dry substance:

First 50 – 60 days	22.0 – 25.0 lbs.
Second 50 – 60 days	21.0 – 24.0 lbs.
Third 50 – 60 days	18.0 – 22.0 lbs.

Comparing these values with those given in Table 5, it is seen that the steers in this experiment made good gains on considerably less dry substance than prescribed by the Henry-Morrison standards.

[1] Henry and Morrison: Feeds and Feeding, 15th ed., (1915), page 667; or Bull: Principles of Feeding Farm Animals, (1916), page 355.

[2] Feeds and Feeding, 15th ed., (1915), page 671.

TABLE 5.—DRY SUBSTANCE CONSUMED DAILY PER 1000 POUNDS LIVE WEIGHT
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot					One-Third-Feed Lot				
			Steer 653	Steer 650	Steer 656	Steer 658	Average	Steer 667	Steer 666	Steer 669	Steer 662	Average
1	1–5	1:1:0	11.65	11.31	11.36	10.95	11.32	16.07	15.04	14.85	14.68	15.16
2	8–13	1:3:0	8.50	9.20	9.09	8.71	8.88	13.82	13.21	13.29	13.04	13.37
3	17–22	1:5:0	7.68	8.38	8.34	7.77	8.04	10.73	11.00	11.14	10.88	10.94
4	25–30	1:4:1	8.08	8.03	8.09	7.62	7.95	10.26	10.02	10.03	9.80	10.03
5	34–37	1:4:1	15.86	14.46	7.35	7.17	7.26[4]	13.98	13.94	9.35	9.20	9.27[4]
			Two-Thirde-Feed Lot					Full-Feed Lot				
			Steer 668	Steer 652[1]	Steer 665	Steer 657	Average	Steer 659[2]	Steer 663[3]	Steer 661	Steer 664	Average
1	1–5	1:1:0	20.71	18.68	18.98	17.26	18.91	23.44	21.57	21.00	22.45	22.12
2	8–13	1:3:0	19.20	17.08	17.52	16.38	17.55	20.27	18.83	20.58	22.94	20.66
3	17–22	1:5:0	14.69	13.09	14.42	13.72	14.05	16.33	13.88	14.81	17.45	15.62
4	25–30	1:4:1	13.68	11.37	12.51	11.08	12.16	15.06	11.59	14.45	15.72	14.20
5	34–37	1:4:1	14.31	12.61	11.76	10.94	11.35[4]	....	....	13.18	13.59	13.39

[1]Removed at end of 34th week.
[2]Removed at end of 33d week.
[3]Removed at end of 30th week.
[4]Average of two steers, as Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

From our results it seems safe to conclude that steers may be maintained or fattened with the ordinary rations of the corn-belt on a smaller allowance of dry substance than the amounts prescribed by the generally accepted feeding standards.

DIGESTIBLE DRY SUBSTANCE CONSUMED

As the coefficients of digestibility of the rations of two steers of each lot were determined for each period of the experiment, data are provided whereby one may calculate the consumption of digestible nutrients of each lot with a considerable degree of accuracy. The results given in Table 6 have been calculated on the assumption that the steers not in the digestion stalls digested their rations as completely as their lot mates in the digestion stalls.

The relation of the different lots with respect to the amounts of total dry substance and the amounts of digestible dry substance consumed is not the same, because of the fact that when a large proportion of the ration consisted of roughage, the coefficients of digestibility of the dry substance varied inversely with the amount of feed consumed.[1]

DIGESTIBLE CRUDE PROTEIN CONSUMED

The amounts of digestible crude protein consumed daily per 1000 pounds live weight are shown in Table 7. In the case of the maintenance lot, the amount of digestible protein in the ration varied from 0.39 pound in Period 3 to 0.81 pound in Period 4. It should be noted particularly that in Periods 2 and 3, when these steers were actually on a maintenance ration (as indicated by the live weight), the average consumption of digestible protein was 0.44 and 0.39 pound, respectively. It is also of interest to note that Steers 650 and 656, which were in the metabolism test, maintained positive weekly nitrogen balances. As a matter of fact, in Period 2, Steer 650 retained 25.1 percent, and Steer 656 retained 25.0 percent of the nitrogen digested. In Period 3, Steer 650 retained 25.7 percent, and Steer 656 retained 28.5 percent of the nitrogen digested. Such a retention indicates that less digestible protein would have been sufficient for maintenance. In Period 1, when Steers 650 and 656 were consuming 0.56 and 0.65 pound of digestible protein, respectively, they retained 34.8 percent and 36.6 percent, respectively, of the nitrogen digested. Steer 650 made an average daily gain of 1.6 pounds during this period, and Steer 656 made an average daily gain of 2.0 pounds.

Armsby,[2] after reviewing the available data upon the protein requirements for maintenance, states: "It seems safe to estimate 0.6

[1] Ill. Agr. Exp. Sta. Bul. 172 (1914).

[2] U. S. Dept. of Agr. Bur. of Anim. Indus. Bul. 143 (1912), page 94.

TABLE 6.—DIGESTIBLE DRY SUBSTANCE CONSUMED DAILY PER 1000 POUNDS LIVE WEIGHT
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot					One-Third-Feed Lot				
			Steer 653	Steer 650	Steer 656	Steer 658	Average	Steer 667	Steer 666	Steer 669	Steer 662	Average
1	1–5	1:1:0	8.07	7.76	7.95	7.58	7.84	10.59	10.34	9.36	9.67	9.99
2	8–13	1:3:0	6.61	7.08	7.14	6.77	6.90	10.01	9.64	9.46	9.37	9.62
3	17–22	1:5:0	6.05	6.57	6.60	6.12	6.34	8.13	8.26	8.52	8.24	8.29
4	25–30	1:4:1	6.42	6.45	6.39	6.06	6.33	7.89	7.79	7.63	7.53	7.71
5	34–37	1:4:1	11.98	10.84	5.85	5.54	5.69[3]	10.58	10.31	7.22	6.96	7.09[4]
			Two-Thirds-Feed Lot					Full-Feed Lot				
			Steer 668	Steer 652[1]	Steer 665	Steer 657	Average	Steer 659[2]	Steer 663[3]	Steer 661	Steer 664	Average
1	1–5	1:1:0	13.23	11.98	12.05	11.03	12.07	14.69	13.70	13.01	14.07	13.87
2	8–13	1:3:0	13.22	11.85	11.97	11.27	12.08	13.11	13.05	12.36	14.84	13.34
3	17–22	1:5:0	11.01	9.97	10.25	10.10	10.33	11.38	10.28	9.66	12.16	10.87
4	25–30	1:4:1	10.27	8.83	9.07	8.39	9.14	11.44	9.18	10.54	11.95	10.78
5	34–37	1:4:1	10.60	9.73	8.51	8.11	8.31[4]	....	....	9.97	10.34	10.16

[1]Removed at end of 34th week.
[2]Removed at end of 33d week.
[3]Removed at end of 30th week.
[4]Average of two steers, as Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

TABLE 7.—DIGESTIBLE CRUDE PROTEIN CONSUMED DAILY PER 1000 POUNDS LIVE WEIGHT
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot					One-Third-Feed Lot				
			Steer 653	Steer 650	Steer 656	Steer 658	Average	Steer 667	Steer 666	Steer 669	Steer 662	Average
1	1–5	1:1:0	0.62	0.56	0.65	0.58	0.60	0.84	0.82	0.74	0.77	0.79
2	8–13	1:3:0	0.42	0.44	0.45	0.43	0.44	0.71	0.67	0.69	0.67	0.69
3	17–22	1:5:0	0.37	0.40	0.40	0.37	0.39	0.53	0.54	0.56	0.54	0.54
4	25–30	1:4:1	0.83	0.83	0.82	0.78	0.81	1.02	0.99	1.00	0.97	0.99
5	34–37	1:4:1	1.63	1.47	0.77	0.74	0.75[4]	1.42	1.34	0.98	0.93	0.95[4]
			Two-Thirds-Feed Lot					Full-Feed Lot				
			Steer 668	Steer 652[1]	Steer 665	Steer 657	Average	Steer 659[2]	Steer 663[3]	Steer 661	Steer 664	Average
1	1–5	1:1:0	0.98	0.88	0.90	0.82	0.90	1.08	1.04	0.96	1.03	1.03
2	8–13	1:3:0	0.93	0.81	0.87	0.79	0.85	0.87	0.85	0.85	0.99	0.89
3	17–22	1:5:0	0.69	0.60	0.67	0.63	0.65	0.75	0.66	0.65	0.80	0.72
4	25–30	1:4:1	1.33	1.12	1.20	1.09	1.18	1.51	1.19	1.39	1.57	1.41
5	34–37	1:4:1	1.45	1.31	1.15	1.11	1.13[4]	...	...	1.34	1.34	1.34

[1]Removed at end of 34th week.
[2]Removed at end of 33d week.
[3]Removed at end of 30th week.
[4]Average of two steers, as Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

pound of crude protein or 0.5 pound of true protein per 1000 pounds live weight as representing in a general way the minimum protein requirement of mature cattle with a probable range of 0.1 or 0.2 pound either way under varying conditions." The fact that Steers 650 and 656 of this experiment when consuming rations containing from 0.40 and 0.65 pound of digestible protein stored from 25 to 37 percent of the digested nitrogen for a period of twenty-two weeks proves that under the conditions of this experiment cattle may be maintained on considerably less protein than the generally accepted standards.

In the case of the one-third-feed lot the protein consumption varied from 0.54 pound in Period 3 to 0.99 pound in Period 4. The two-thirds-feed lot received from 0.65 pound in Period 3 to 1.18 pounds in Period 4, while the full-feed lot received from 0.72 pound in Period 3 to 1.41 pounds in Period 4. It is of interest to compare the protein consumption of the steers in this experiment with the amount of protein prescribed by the Wolff-Lehmann and the Henry-Morrison feeding standards. Such a comparison is shown in Table 8.

TABLE 8.—COMPARISON OF PROTEIN CONSUMPTION WITH THE WOLFF-LEHMANN AND HENRY-MORRISON STANDARDS[1]

Period	One-third-feed lot	Two-thirds-feed lot	Full-feed lot	Wolff-Lehmann	Henry-Morrison
1	0.79	0.90	1.03		
2	0.69	0.85	0.89	2.5	2.0 – 2.3
3	0.54	0.65	0.72	3.0	1.9 – 2.3
4	0.99	1.18	1.41	2.7	1.8 – 2.1
5	0.95[2]	1.13[3]	1.34		

[1]While the periods of this experiment do not correspond exactly with the periods given in these standards, yet the results are comparable in a general way.

[2]Average of Steers 669 and 662.

[3]Average of Steers 665 and 667.

When one considers that the steers of the two-thirds-feed lot made an average daily gain of 1.8 pounds and the steers of the full-feed lot made an average daily gain of 2.1 pounds for a period of thirty-seven weeks, it seems safe to conclude that the above-mentioned standards for the protein requirements of fattening steers are unnecessarily high.

NET ENERGY CONSUMED

Knowing the amounts of digestible protein, carbohydrates, and fats consumed, it was possible to calculate the consumption of net energy, with at least a fair degree of accuracy, using the method of Kellner[1] and Armsby.[2] For the sake of comparison, these results

[1]The Scientific Feeding of Animals (1911), page 82.

[2]Pa. Agr. Exp. Sta. Bul. 71 (1905), page 14.

were calculated to the amounts consumed daily per 1000 pounds live weight. Some difficulty was encountered in making these calculations. It is generally accepted that the energy requirement for maintenance varies, not directly with the weight of the animal, but with the surface or approximately with the two-thirds power of the live weight of the body. On the other hand, however, it has not been shown that the energy requirement above maintenance varies with the surface of the body. Consequently, the results have been calculated in two ways: Table 9 shows the results calculated upon the assumption that the energy requirements varied according to the surface of the body; and Table 10 shows the results calculated upon the assumption that the energy requirements vary directly with the body weight. Inasmuch as at least half of the energy was used for maintenance, even in the full-feed lot, we feel that Table 9 is a better basis for a discussion of the energy consumption than Table 10.

It is of interest to compare the energy required by these steers for maintenance with the findings of other investigators. Armsby[1] has summarized the investigations upon the energy requirements for the maintenance of cattle. To his summary we have added the recent results of Trowbridge, Moulton, and Haigh.[2] The summarized results are shown in Table 11. Comparing these results with the energy consumption of the four steers of the maintenance lot when they were actually on a maintenance ration (as indicated by the live weights), in Periods 2 and 3, it is seen that there is but little difference between the average requirements for the maintenance of thin cattle as reported by other investigators and the average requirement of these maintenance steers in Periods 2 and 3. In the former case the average requirement is 6.46 therms, while in the latter it is 6.62 therms, with individual variations ranging from 6.14 to 7.00 therms. It is of interest to note that in Period 4 the energy consumption of the maintenance steers was reduced to 6.41 therms, yet during this period they made an average daily gain of 0.85 pound.

A study of the energy consumption of the steers in the other lots does not reveal anything of especial interest.

[1] U. S. Dept. of Agr. Bur. of Anim. Indus. Bul. 143 (1912), page 39.

[2] Mo. Exp. Sta. Res. Bul. 18 (1915).

TABLE 9.—NET ENERGY CONSUMED DAILY PER 1000 POUNDS LIVE WEIGHT[1]
(Results expressed in therms)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot					One-Third-Feed Lot				
			Steer 653	Steer 650	Steer 656	Steer 658	Average	Steer 667	Steer 666	Steer 669	Steer 662	Average
1	1–5	1:1:0	7.13	6.98	7.13	6.88	7.03	9.52	9.46	8.64	8.99	9.15
2	8–13	1:3:0	6.43	6.95	7.00	6.71	6.77	10.01	9.80	9.77	9.77	9.84
3	17–22	1:5:0	6.14	6.73	6.73	6.34	6.48	8.85	8.87	9.35	9.22	9.07
4	25–30	1:4:1	6.37	6.59	6.47	6.23	6.41	8.58	8.37	8.41	8.45	8.45
5	34–37	1:4:1	12.39	12.28	6.03	5.74	5.88[5]	11.79	11.49	6.74	7.88	7.31[6]
			Two-Thirds-Feed Lot					Full-Feed Lot				
			Steer 668	Steer 652[2]	Steer 665	Steer 657	Average	Steer 659[3]	Steer 663[4]	Steer 661	Steer 664	Average
1	1–5	1:1:0	11.92	11.05	11.17	10.57	11.18	13.62	12.69	12.43	13.21	12.99
2	8–13	1:3:0	13.36	12.25	12.59	12.21	12.60	13.72	13.67	13.20	15.54	14.03
3	17–22	1:5:0	12.02	11.16	11.55	11.75	11.62	12.63	11.53	10.75	13.58	12.12
4	25–30	1:4:1	11.31	9.90	10.86	9.87	10.48	13.21	10.52	12.22	14.19	12.53
5	34–37	1:4:1	12.11	11.27	9.88	9.69	9.78[5]	....	....	11.96	12.31	12.13

[1]Assuming that the energy requirements vary directly as the two-thirds power of the live weight.
[2]Removed at end of 34th week.
[3]Removed at end of 33d week.
[4]Removed at end of 30th week.
[5]Average of two steers, as Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

TABLE 10.—NET ENERGY CONSUMED DAILY PER 1000 POUNDS LIVE WEIGHT[1]
(Results expressed in therms)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot					One-Third-Feed Lot				
			Steer 653	Steer 650	Steer 656	Steer 658	Average	Steer 667	Steer 666	Steer 669	Steer 662	Average
1	1–5	1:1:0	7.65	7.37	7.54	7.19	7.44	10.02	9.81	8.84	9.15	9.46
2	8–13	1:3:0	6.80	7.30	7.33	6.97	7.10	10.33	9.93	9.78	9.67	9.93
3	17–22	1:5:0	6.44	7.02	7.01	6.51	6.75	8.70	8.85	9.09	8.82	8.87
4	25–30	1:4:1	6.76	6.80	6.69	6.37	6.65	8.33	8.23	8.05	7.95	8.14
5	34–37	1:4:1	12.56	12.10	6.18	5.82	6.00[5]	11.14	10.86	7.59	7.33	7.46[5]
			Two-Thirds-Feed Lot					Full-Feed Lot				
			Steer 668	Steer 652[2]	Steer 665	Steer 657	Average	Steer 659[3]	Steer 663[4]	Steer 661	Steer 664	Average
1	1–5	1:1:0	12.46	11.31	11.35	10.39	11.38	13.84	12.92	12.21	13.23	13.05
2	8–13	1:3:0	13.61	12.17	12.33	11.60	12.43	13.42	13.38	12.63	15.18	13.65
3	17–22	1:5:0	11.77	10.69	10.96	10.79	11.05	11.98	10.97	10.03	12.80	11.45
4	25–30	1:4:1	10.82	9.28	9.58	8.84	9.63	12.05	9.67	11.07	12.96	11.44
5	34–37	1:4:1	11.18	10.37	8.98	8.55	8.76[5]	....	....	10.45	10.86	10.66

[1]Assuming that the energy requirements vary directly with the live weight.
[2]Removed at the end of 34th week.
[3]Removed at the end of 33d week.
[4]Removed at the end of 30th week.
[5]Average of two steers, as Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

TABLE 11.—SUMMARY OF INVESTIGATIONS UPON THE ENERGY REQUIREMENTS OF CATTLE

(Results expressed in therms of net energy per 1000 pounds live weight)

Investigator	Condition of animals	No. of animals	No. of trials	Net energy			Remarks
				Maximum	Minimum	Average	
Armsby and Fries	Thin	3	7	7.06	4.86	6.11	Respiration experiment
Kellner	"	7	7	7.32	5.31	6.20	Respiration experiment
Armsby	"	3	10	7.60	6.62	7.02	Respiration experiment; fed roughage
Armsby	"	3	3	6.26	4.88	5.62	Respiration experiment; fed much grain
Haecker	"	3	5	6.45	5.30	5.71	Live-weight experiment
Evvard	"	3	3	7.85	6.45	7.18	Live-weight experiment
Evvard	"	1	1	...	...	8.09	Live-weight experiment
Trowbridge et al.	"	10	13	7.84	5.31	6.55	Live-weight experiment
Trowbridge et al.	Good	7	9	8.68	6.28	7.42	Live-weight experiment
Trowbridge et al.	Fat	4	5	6.73	6.05	6.39	Live-weight experiment
Kellner	Fat	3	3	9.58	7.75	8.59	Respiration experiment
Evvard	Partly fat	3	3	10.62	8.15	9.07	Live-weight experiment
Average	Thin	33	49	....	...	6.46	Weighted
Average	Good and fat	17	20	....	...	7.59	Weighted
Average	All	50	69	....	...	6.78	Weighted

WEIGHTS AND GAINS

The steers of each lot were weighed individually at 2 p. m. every day of the experiment. The weights of the steers at the beginning of each period and at the end of the experiment are given in Table 12. The initial weights of Period 1 and the final weights of Period 4 are the averages of the first seven days and the last seven days, respectively, of the experiment. The other weights are the averages of five daily weights—the last two days of the preceding transitional period and the first three days of the test period under consideration.

The initial weights of the steers were quite variable, ranging from 762 pounds for Steer 653 of the maintenance lot to 1010 pounds for Steer 657 of the two-thirds-feed lot. There was also considerable variation between the averages of the different lots themselves, the maintenance lot weighing 814 pounds; the one-third-feed lot, 873 pounds; the two-thirds-feed lot, 897 pounds; and the full-feed lot, 926 pounds. These variations in weight may have had some influence upon the results of the experiment.

The individual gains, the average gains per lot, and the total gains per lot, for each period and for the entire experiment are presented in Table 13. The average daily gains are shown in Table 14.

Altho it was the original intention to keep the weight of the maintenance lot practically constant, yet considerable gain was made from the beginning to the end of the experiment. However, these steers

were practically on a maintenance ration during Periods 2 and 3. Beginning with the 31st week, Steers 653 and 650 of the maintenance lot, Steers 667 and 666 of the one-third-feed lot, and Steers 668 and 652 of the two-thirds-feed lot were gradually put on a full-feed ration. Consequently, their gains for the last period of the experiment were as a rule much greater than those of their respective lot mates.

Disregarding the maintenance lot for obvious reasons, it is seen that the rate of gain with the exception of Steer 667 decreased regularly from Period 1 to Period 4, when linseed meal was introduced into the ration. After the introduction of the linseed meal, the gains increased considerably but again decreased in Period 5. In this respect the steers behaved in accordance with the prevalent idea of practical feeders regarding the addition of a nitrogenous concentrate near the end of the fattening period.

As might naturally be expected, the steers on the larger rations made greater gains than those on the small rations, the average daily gains for the various lots being as follows: maintenance lot, 0.70 pound; one-third-feed lot, 1.32 pounds; two-thirds-feed lot, 1.79 pounds; and full-feed lot, 2.13 pounds. It should be remembered, however, that Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5. A study of the data also shows that the individual daily gains of the steers of each lot for the entire experiment were quite uniform except in the case of the maintenance lot, in which two steers received considerably more feed than the others, as explained elsewhere. The data also show that the gains in each period were dependent upon the amount of feed consumed, altho in a few cases the individual gains of one lot overlap those of another lot.

Considering the length of the feeding period and the amounts of feeds consumed, the full-feed lot made especially good gains in spite of the fact that two of the steers were in the digestion stalls continuously during the experiment. Also, the two-thirds-feed lot made fairly good gains for a feeding period of this length, 259 days. As a matter of fact, these steers made as good gains as the full-feed steers in Periods 1 and 3. The gains of the one-third-feed lot, of course, were smaller than one would expect in practical fattening.

The question naturally arises as to what effect the digestion and metabolism experiment had upon the gains of the steers confined in the metabolism stalls. Steers 650 and 656 of the maintenance lot, Steers 666 and 669 of the one-third-feed lot, Steers 652 and 665 of the two-thirds-feed lot, and Steers 663 and 661 of the full-feed lot were in the metabolism and digestion experiment continuously. Their gains were practically as good as those of their lot mates confined in ordinary stalls. Consequently, it seems safe to conclude that the metabolism and digestion steers were under normal conditions and were at most only slightly affected by that phase of the experiment.

TABLE 12.—WEIGHTS OF STEERS AT BEGINNING AND END OF EACH PERIOD
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot					One-Third-Feed Lot				
			Steer 653	Steer 650	Steer 656	Steer 658	Average	Steer 667	Steer 666	Steer 669	Steer 662	Average
1	1	1:1:0	762	814	809	870	814	832	849	901	910	873
1	5	1:1:0	831	869	878	882	865	891	937	970	985	946
2	8	1:3:0	852	864	869	892	869	871	932	978	987	942
2	13	1:3:0	854	859	872	892	869	952	988	1033	1070	1011
3	17	1:5:0	859	879	882	904	881	1007	1000	1053	1100	1040
3	22	1:5:0	854	881	886	910	883	1066	1023	1107	1153	1087
4	25	1:4:1	834	895	891	913	883	1048	1027	1115	1173	1091
4	30	1:4:1	874	930	922	951	919	1139	1084	1178	1239	1160
5[4]	34	1:4:1	910	972	912	961	939[4]	1166	1138	1195	1252	1188[4]
5	37	1:4:1	991	1087	934	965	994	1191	1197	1220	1247	1214
			Two-Thirds-Feed Lot					Full-Feed Lot				
			Steer 668	Steer 652[1]	Steer 665	Steer 657	Average	Steer 659[2]	Steer 663[3]	Steer 661	Steer 664	Average
1	1	1:1:0	824	869	886	1010	897	894	873	1004	932	926
1	5	1:1:0	912	975	1004	1100	998	1000	992	1093	1035	1030
2	8	1:3:0	907	977	1018	1127	1007	1016	1019	1109	1028	1043
2	13	1:3:0	979	1071	1084	1204	1084	1126	1109	1191	1129	1139
3	17	1:5:0	1021	1098	1143	1245	1127	1132	1113	1217	1160	1155
3	22	1:5:0	1090	1161	1186	1318	1189	1201	1202	1255	1216	1218
4	25	1:4:1	1088	1177	1204	1340	1202	1255	1244	1295	1261	1264
4	30	1:4:1	1217	1250	1283	1419	1292	1375	1320	1404	1368	1367
5[4]	34	1:4:1	1239	1275	1309	1434	1314[4]	1422	....	1462	1422	1435
5	37	1:4:1	1291	(1286)	1348	1479	1351	....	....	1518	1475	1497

[1]Removed at end of 34th week.
[2]Removed at end of 33d week.
[3]Removed at end of 30th week.
[4]Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

TABLE 13.—TOTAL GAIN BY EACH STEER PER PERIOD
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot					
			Steer 653	Steer 650	Steer 656	Steer 658	Averags	Total
1	1–5	1:1:0	69	55	69	12	51.2	205
2	8–13	1:3:0	2	–5	3	0	0.0	0
3	17–22	1:5:0	–5	2	4	6	1.7	7
4	25–30	1:4:1	40	35	31	38	36.0	144
5	34–37	1:4:1	81	115	22	4	13.0[4]	26[4]
Total	1–37	.....	229	273	125	95	180.5[5]	722[5]
			One-Third-Feed Lot					
			Steer 667	Steer 666	Steer 669	Steer 662	Average	Total
1	1–5	1:1:0	59	88	69	75	72.7	291
2	8–13	1:3:0	81	56	55	83	68.7	275
3	17–22	1:5:0	59	23	54	53	47.2	189
4	25–30	1:4:1	91	57	63	66	69.2	277
5	34–37	1:4:1	25	59	25	–5	10.0[4]	20[4]
Total	1–37	.....	359	348	319	337	340.7[5]	1363[5]
			Two-Thirds-Feed Lot					
			Steer 668	Steer 652[3]	Steer 665	Steer 657	Average	Total
1	1–5	1:1:0	88	106	118	90	100.5	402
2	8–13	1:3:0	72	94	66	77	77.2	309
3	17–22	1:5:0	69	63	43	73	62.0	248
4	25–30	1:4:1	129	73	79	79	90.0	360
5	34–37	1:4:1	52	11	39	45	42.0[4]	84[4]
Total	1–37	.....	467	417	462	469	453.7[5]	1815[5]
			Full-Feed Lot					
			Steer 659[1]	Steer 663[2]	Steer 661	Steer 664	Averags	Total
1	1–5	1:1:0	106	119	89	103	104.2	417
2	8–13	1:3:0	110	90	82	101	95.7	383
3	17–22	1:5:0	69	89	38	56	63.0	252
4	25–30	1:4:1	120	76	109	107	103.0	412
5	34–37	1:4:1	...	...	56	53	54.5	109
Total	1–37	.....	528	447	514	543	508.0	2032

[1]Removed at end of 33d week.

[2]Removed at end of 30th week.

[3]Removed at end of 34th week.

[4]Two steers only, as Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

[5]Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

TABLE 14.—AVERAGE DAILY GAIN BY EACH STEER PER PERIOD
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot				
			Steer 653	Steer 650	Steer 656	Steer 658	Average
1	1–5	1:1:0	1.97	1.57	1.97	0.34	1.46
2	8–13	1:3:0	0.05	–0.12	0.07	0.00	0.00
3	17–22	1:5:0	–0.12	0.05	0.10	0.14	0.04
4	25–30	1:4:1	0.95	0.83	0.74	0.90	0.85
5	34–37	1:4:1	2.89	4.11	0.78	0.14	0.46[4]
Total	1–37	.....	0.88	1.05	0.48	0.37	0.70[5]
			One-Third-Feed Lot				
			Steer 667	Steer 666	Steer 669	Steer 662	Average
1	1–5	1:1:0	1.69	2.51	1.97	2.14	2.08
2	8–13	1:3:0	1.93	1.33	1.31	1.98	1.64
3	17–22	1:5:0	1.40	0.55	1.29	1.26	1.12
4	25–30	1:4:1	2.17	1.36	1.50	1.57	1.65
5	34–37	1:4:1	0.89	2.11	0.89	–0.18	0.37[4]
Total	1–37	.....	1.39	1.34	1.23	1.30	1.32[5]
			Two-Thirds-Feed Lot				
			Steer 668	Steer 652[3]	Steer 665	Steer 657	Average
1	1–5	1:1:0	2.51	3.03	3.37	2.57	2.87
2	8–13	1:3:0	1.71	2.24	1.57	1.83	1.84
3	17–22	1:5:0	1.64	1.50	1.02	1.74	1.48
4	25–30	1:4:1	3.07	1.74	1.88	1.88	2.14
5	34–37	1:4:1	1.86	1.57	1.39	1.61	1.50[4]
Total	1–37	.....	1.80	1.75	1.78	1.81	1.79[5]
			Full-Feed Lot				
			Steer 659[1]	Steer 663[2]	Steer 661	Steer 664	Average
1	1–5	1:1:0	3.03	3.40	2.54	2.94	2.98
2	8–13	1:3:0	2.62	2.14	1.95	2.40	2.28
3	17–22	1:5:0	1.64	2.12	0.90	1.33	1.50
4	25–30	1:4:1	2.86	1.81	2.60	2.55	2.45
5	34–37	1:4:1	...	...	2.00	1.89	1.95
Total	1–37	.....	2.29	2.13	1.98	2.10	2.13

[1]Removed at end of 33d week.

[2]Removed at end of 30th week.

[3]Removed at end of 34th week.

[4]Average of two steers as Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

[5]Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

INFLUENCE OF AMOUNT OF RATION UPON THE ECONOMY OF GAINS

The practical cattle feeder assumes that the larger the amount of feed that fattening cattle consume, the more economical will be the gains. This assumption is based upon the fact that a certain amount of feed is required for maintenance under any condition. Consequently, the larger the proportion of feed above maintenance, the more there is above the maintenance requirement available for production, and for this reason the ration is assumed to be more economical.

On the other hand, experiments at the Illinois, Missouri, and other stations show that large rations are not as completely digested as smaller ones, especially when there is a considerable amount of crude fiber in the ration. Consequently, if one considers only the digestibility of the ration, one would expect the economy to be lessened as the ration is increased. Thus in studying the influence of the amount of ration upon economy, both of these factors, working in opposite directions, must be considered.

In studying the economy of gains, there are several measures by which we may determine it. The practical feeder usually measures the economy of gains by the amount of feed consumed per pound of gain. This is not strictly accurate, owing to variations in the chemical composition of the feeds, especially in the water content. Furthermore, when several feeds are used, as in this experiment, such a large amount of data is presented as to be confusing. The expression of the economy of the gains in terms of the consumption of dry substance per pound of gain obviates both of the previous objections, but this alone is not entirely satisfactory, owing to the fact that the dry substance from some feeds is more digestible than that from others. To dispose of this difficulty the economy of the gains may be expressed also in terms of digestible dry substance consumed per pound of gain. However, this is not altogether satisfactory, as the animal does not necessarily utilize the energy of feeds in direct proportion to the amount of digestible nutrients in the feeds. The use of the net energy consumed per pound of gain disposes of this objection. Theoretically, at least, the net energy consumed per pound of gain is the most accurate measure of the economy of gains. However, the inaccuracies involved in the calculation of the net energy detract from its practical value. For the purpose of this investigation, the amounts of feed, of total dry substance, of digestible dry substance, and of net energy consumed per pound of gain have been used as measures of the economy of the gains.

The amounts of feeds consumed per pound of gain by the individual steers are shown in Table 15. The amounts of feed consumed per pound of gain by the different lots are shown in Table 16. Dis-

TABLE 15.—FEEDS CONSUMED BY EACH STEER PER POUND OF GAIN
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal
Maintenance Lot														
			Steer 653[2]			Steer 650[2]			Steer 656			Steer 658		
1	1–5	1:1:0	2.74	2.74	...	3.50	3.50	...	2.79	2.79	...	16.05	16.05	...
2	8–13	1:3:0	43.56	130.68	...	....[1]	....[1]	...	31.87	95.61	...	....[1]	....[1]	...
3	17–22	1:5:0	...[1]	...[1]	...	29.40	147.00	...	14.70	73.50	...	9.52	47.60	...
4	25–30	1:4:1	1.35	5.40	1.35	1.66	6.66	1.66	1.88	7.51	1.88	1.50	5.98	1.50
5	34–37	1:4:1	1.01	4.04	1.01	0.71	2.84	0.71	1.68	6.72	1.68	9.24	36.96	9.24
Total	1–37	.....	2.60	7.38	0.78	2.30	6.56	0.68	4.62	12.72	1.07	6.02	16.51	1.40
One-Third-Feed Lot														
			Steer 667[2]			Steer 666[2]			Steer 669			Steer 662		
1	1–5	1:1:0	4.68	4.68	...	3.07	3.07	...	4.03	4.03	...	3.72	3.72	...
2	8–13	1:3:0	1.89	5.67	...	2.74	8.22	...	2.91	8.72	...	1.95	5.85	...
3	17–22	1:5:0	1.58	7.63	...	3.85	19.23	...	1.78	8.89	...	1.87	9.35	...
4	25–30	1:4:1	0.98	3.93	0.98	1.47	5.89	1.47	1.44	5.76	1.44	1.42	5.68	1.42
5	34–37	1:4:1	3.56	14.22	3.56	1.50	6.01	1.50	2.42	9.68	2.42	...[1]	...[1]	...[1]
Total	1–37	.....	2.54	7.26	0.69	2.56	7.29	0.68	2.83	7.99	0.67	2.72	7.71	0.65
Two-Thirds-Feed Lot														
			Steer 668[2]			Steer 652[2]			Steer 665			Steer 657		
1	1–5	1:1:0	4.13	4.13	...	3.29	3.29	...	3.07	3.07	...	4.05	4.05	...
2	8–13	1:3:0	3.05	9.15	...	2.24	6.71	...	3.40	10.22	...	2.98	8.95	...
3	17–22	1:5:0	1.84	9.19	...	1.89	9.47	...	3.13	15.63	...	1.94	9.70	...
4	25–30	1:4:1	0.97	3.87	0.97	1.50	6.01	1.50	1.56	6.24	1.56	1.57	6.28	1.57
5	34–37	1:4:1	1.87	7.50	1.87	1.96	7.82	1.96	2.15	8.62	2.15	1.90	7.59	1.90
Total	1–37	.....	2.63	7.54	0.67	2.59	7.15	0.51	2.64	7.58	0.64	2.67	7.71	0.64
Full-Feed Lot														
			Steer 659			Steer 663			Steer 661			Steer 664		
1	1–5	1:1:0	4.23	4.23	...	3.43	3.43	...	4.99	4.99	...	4.34	4.34	...
2	8–13	1:3:0	2.37	7.14	...	2.68	8.04	...	3.46	10.38	...	2.94	8.83	...
3	17–22	1:5:0	2.21	11.05	...	1.44	7.22	...	3.81	19.06	...	2.96	14.82	...
4	25–30	1:4:1	1.32	5.26	1.32	1.56	6.22	1.56	1.43	5.71	1.43	1.54	6.14	1.54
5	34–37	1:4:1	...	...	...	...	...	...	1.88	7.51	1.88	1.99	7.98	1.99
Total	1–37	.....	2.61	7.21	0.49	2.56	6.72	0.32	2.91	8.27	0.72	2.89	8.37	0.71

[1]Animal lost weight. [2]On full feed in Period 5.

TABLE 16.—FEEDS CONSUMED BY EACH LOT PER POUND OF GAIN
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot			One-Third-Feed Lot			Two-Thirds-Feed Lot			Full-Feed Lot		
			Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal
1	1–5	1:1:0	3.74	3.74	...	3.79	3.79	...	3.58	3.58	...	4.19	4.19	...
2	8–13	1:3:0	...[2]	...[2]	...	2.29	6.85	...	2.86	8.58	...	2.83	8.49	...
3	17–22	1:5:0	32.52[1]	162.60[1]	...	1.98	9.88	...	2.11	10.53	...	2.35	11.74	...
4	25–30	1:4:1	1.58	6.32	1.58	1.29	5.17	1.29	1.34	5.35	1.34	1.45	5.79	1.45
5	34–37	1:4:1	2.84	11.37	2.84[3]	6.08	24.34	6.08[3]	2.02	8.07	2.02[3]	1.94	7.74	1.94
Total	1–37	.....	3.29	9.20	0.87	2.66	7.55	0.67	2.63	7.51	0.62	2.75	7.68	0.57

[1]One or more steers in lot lost in weight.
[2]Lot made no gain.
[3]Two steers only, as Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

cussion of these tables is omitted, since the discussion pertaining to the consumption of dry substance per pound of gain also applies to them.

Dry Substance, Digestible Dry Substance, and Net Energy Consumed per Pound of Gain.—The total dry substance, the digestible dry substance, and the net energy consumed per pound of gain are shown in Tables 17, 18, and 19, respectively. Considering the data for the one-third-feed lot, the two-thirds-feed lot, and the full-feed lot during the different periods of the experiment, there is no evidence that one lot was any more efficient than another. Taking the entire thirty-seven weeks of the experiment into consideration, there seems to be no reason to conclude that the amount of feed consumed had any effect upon the economy of gains, as indicated by the amount of dry substance, digestible dry substance, and net energy consumed per pound of gain.

It is of interest to note that Steers 653 and 650 of the maintenance lot made much more efficient gains in Period 5 when put upon full feed than the steers which had been receiving full-feed rations previous to Period 5. On the other hand, Steers 667 and 666 of the one-third-feed lot, and Steers 668 and 652 of the two-thirds-feed lot made no more economical gains when put upon a full-feed ration than the steers of the full-feed lot.

INFLUENCE OF CHARACTER OF FEED UPON THE ECONOMY OF GAINS

The fact that the steers were fed different proportions of corn and hay during the first three periods of the experiment and the fact that in Period 4 linseed meal was substituted for a part of the corn in the ration, provide data for studying the influence of a decrease in roughage together with an increase in concentrates upon the economy of gains, and also the effect of adding linseed meal to a ration high in concentrates and low in roughages. In this connection, however, it must be remembered that other factors such as the age and more especially the condition of the animals may have had considerable effect upon the economy of gains in different periods.

Influence of Change from Hay 1 Part and Corn 1 Part, to Hay 1 Part and Corn 3 Parts.—In Period 1 the ration consisted of equal parts of clover hay and ground corn. In the transitional period after Period 1, the hay was decreased and the corn increased, so that in Period 2 the ration consisted of one part of hay and three parts of corn. From Table 5, page 576, it is seen that the total dry substance consumed daily was slightly reduced in Period 2, while the consumption of digestible dry substance was practically the same as shown in Table 6. Table 7 shows that there was a decrease in the amount of digestible crude protein consumed in Period 2, while Table 10 shows

TABLE 17.—TOTAL DRY SUBSTANCE CONSUMED BY EACH STEER PER POUND OF GAIN
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot					One-Third-Feed Lot				
			Steer 653	Steer 650	Steer 656	Steer 658	Lot	Steer 667	Steer 666	Steer 669	Steer 662	Lot
1	1–5	1:1:0	4.78	6.11	4.87	28.00	6.53	8.17	5.35	7.03	6.49	6.61
2	8–13	1:3:0	151.55	....[1]	110.91	....[2]	....[1]	6.57	9.54	10.12	6.78	7.95
3	17–22	1:5:0	...[1]	155.14	77.57	50.23	171.60	8.05	20.30	9.38	9.86	10.43
4	25–30	1:4:1	7.13	8.78	9.91	7.89	8.33	5.18	7.78	7.60	7.50	6.81
5	34–37	1:4:1	5.26	3.69	8.66	48.32	14.76[3]	18.59	7.82	12.60	...[1]	31.75[3]
Total	1–37	.....	9.40	8.34	16.07	20.92	11.67	9.17	9.20	10.04	9.68	9.51

			Two-Thirds-Feed Lot					Full-Feed Lot				
			Steer 668	Steer 652	Steer 665	Steer 657	Lot	Steer 659	Steer 663	Steer 661	Steer 664	Lot
1	1–5	1:1:0	7.21	5.74	5.37	7.08	6.25	7.38	6.02	8.71	7.60	7.33
2	8–13	1:3:0	10.61	7.78	11.85	10.38	9.96	8.27	9.35	12.06	10.25	9.86
3	17–22	1:5:0	9.70	9.91	16.47	10.23	11.08	11.67	7.64	20.16	15.64	12.41
4	25–30	1:4:1	5.11	7.93	8.23	8.28	7.06	6.94	8.22	7.54	8.11	7.64
5	34–37	1:4:1	9.80	10.30	11.21	9.93	10.53[3]	...	...	9.88	10.43	10.15
Total	1–37	.....	9.48	8.95	9.49	9.64	9.40	9.03	8.41	10.43	10.47	9.63

[1]Lost in weight.
[2]Made no gain.
[3]Two steers only, as Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

TABLE 18.—DIGESTIBLE DRY SUBSTANCE CONSUMED BY EACH STEER PER POUND OF GAIN
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot					One-Third-Feed Lot				
			Steer 653	Steer 650	Steer 656	Steer 658	Lot	Steer 667	Steer 666	Steer 669	Steer 662	Lot
1	1–5	1:1:0	3.31	4.19	3.41	19.40	4.52	5.38	3.68	4.44	4.28	4.36
2	8–13	1:3:0	117.81	....[1]	87.31	....[2]	....[1]	4.73	6.92	7.20	4.88	5.71
3	17–22	1:5:0	...[1]	121.64	61.35	39.55	135.13	6.10	15.24	7.18	7.47	7.91
4	25–30	1:4:1	5.67	7.05	7.82	6.28	6.63	3.98	6.04	5.78	5.77	5.24
5	34–37	1:4:1	3.97	2.77	6.89	37.35	11.57[3]	14.06	5.78	9.73	...[1]	24.27[3]
Total	1–37	.....	7.19	6.33	12.42	16.05	8.94	6.73	6.78	7.29	7.09	6.96

			Two-Thirds-Feed Lot					Full-Feed Lot				
			Steer 668	Steer 652	Steer 665	Steer 657	Lot	Steer 659	Steer 663	Steer 661	Steer 664	Lot
1	1–5	1:1:0	4.60	4.63	3.41	4.52	3.99	4.62	3.82	5.40	4.76	4.59
2	8–13	1:3:0	7.30	5.40	8.09	7.14	6.85	5.35	6.48	7.24	6.63	6.36
3	17–22	1:5:0	7.14	7.54	11.71	7.53	8.15	8.13	5.66	13.16	10.90	8.63
4	25–30	1:4:1	3.83	6.16	5.96	6.22	5.30	5.28	6.50	5.50	6.16	5.79
5	34–37	1:4:1	7.26	7.95	8.12	7.36	7.71[3]	...	...	7.47	7.93	7.70
Total	1–37	.....	6.74	6.48	6.58	6.86	6.67	6.17	5.95	6.91	7.23	6.60

[1]Lost in weight.
[2]Made no gain.
[3]Two steers only, as Steers 653, 650, 667, 666, 668, and 652 were on full feed in Period 5.

TABLE 19.—NET ENERGY CONSUMED BY EACH STEER PER POUND OF GAIN
(Results expressed in therms)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot					One-Third-Feed Lot				
			Steer 653	Steer 650	Steer 656	Steer 658	Lot	Steer 667	Steer 666	Steer 669	Steer 662	Lot
1	1–5	1:1:0	3.14	3.98	3.24	18.40	4.29	5.09	3.50	4.18	4.04	4.12
2	8–13	1:3:0	121.17	....[1]	89.38	....[2]	....[1]	4.88	7.15	7.45	5.03	5.90
3	17–22	1:5:0	...[1]	129.86	65.13	42.12	143.87	6.53	16.33	7.67	8.00	8.46
4	25–30	1:4:1	5.96	7.43	8.20	6.60	6.97	4.20	6.38	6.10	6.09	5.53
5	34–37	1:4:1	4.17	3.09	7.28	39.22	12.19[3]	14.81	6.09	10.22	...	25.50[3]
Total	1–37	.....	7.43	6.63	12.79	16.54	9.26	6.97	7.04	7.55	7.35	7.22
			Two-Thirds-Feed Lot					Full-Feed Lot				
			Steer 668	Steer 652	Steer 665	Steer 657	Lot	Steer 659	Steer 663	Steer 661	Steer 664	Lot
1	1–5	1:1:0	4.34	3.48	3.21	4.26	3.76	4.35	3.61	5.06	4.48	4.32
2	8–13	1:3:0	7.52	5.54	8.33	7.35	7.05	5.47	6.65	7.40	6.78	6.51
3	17–22	1:5:0	7.63	8.09	12.53	8.05	8.72	8.56	6.04	13.65	11.47	9.08
4	25–30	1:4:1	4.04	6.48	6.29	6.55	5.58	5.56	6.87	5.77	6.68	6.15
5	34–37	1:4:1	7.66	8.47	8.56	7.76	8.13[3]	...	...	7.83	8.34	8.08
Total	1–37	.....	6.98	6.67	6.82	7.10	6.90	6.33	6.10	6.88	7.48	6.73

[1]Lost in weight.
[2]Made no gain.
[3]Two steers only, as Steers 653, 650, 667, 666, 665, and 657 were on full feed in Period 5.

a slight increase in the consumption in net energy. Thus these figures reveal but little difference in the nutrients consumed in Periods 1 and 2 except that there was less protein consumed in Period 2 than in Period 1.

As shown in Table 14, page 588, the gains made in Period 2 were much lower than those made in Period 1. Especially was this true in case of the two-thirds-feed lot, which dropped from an average gain of 2.87 pounds to 1.84 pounds. The full-feed lot decreased from 2.98 pounds per day to 2.28 pounds per day, while the one-third-feed lot decreased from 2.08 to 1.64 pounds. The decrease in the individual gains, with the exception of Steer 667, was just as marked as the decrease in the average gains.

A study of the individual data in Table 17, page 593, shows that the economy of gains as measured by the consumption of dry substance was decreased in Period 2 with but one exception—Steer 667. Table 18 shows that, with the exception just noted, the amount of digestible dry substance necessary to produce a pound of gain was much greater in Period 2 than in Period 1. Table 19 shows that the economy as measured by the consumption of net energy per pound of gain was much decreased in Period 2.

One would not expect such marked differences in the rate of gain and the economy of gains between Periods 1 and 2 as were shown by the steers in this experiment. Of course, it is a well known fact that the economy of gains decreases with the increasing age and condition of the animal. However, it would not seem that the few weeks difference between Periods 1 and 2 would have such a marked effect. It is possible that the decrease in consumption of digestible crude protein may have been responsible for the decrease in the rate and economy of gains. However, the decrease in protein consumption was not great, varying from 0.03 pound to 0.21 pound per day. As a matter of fact, there was no correlation between the decrease in protein consumption and the decrease in efficiency among the individual steers. Consequently, we are unable to explain these results which seem contrary to general opinion.

Influence of Change from Hay 1 Part and Corn 3 Parts, to Hay 1 Part and Corn 5 Parts.—During the second transitional period the hay of the ration was gradually decreased and the corn was increased, so that during Period 3 the ration consisted of hay 1 part and corn 5 parts.

There was a considerable reduction in the consumption of total dry substance in Period 3 owing to the reduction of the roughage and the increase of the concentrates of the ration. These data are given in Table 5. The data of Table 6 show that there was a considerable reduction also in the amount of digestible dry substance consumed, altho there was not as great a difference between Periods 2 and 3 as

in the case of the total dry substance. The consumption of digestible crude protein in Period 3 was considerably lower than in Period 2, as is shown by the data in Table 7. As a matter of fact, the protein consumption of most of the steers was below, or no greater than, the ordinary standards for maintenance. Table 9, page 582, shows that the consumption of net energy in Period 3 was considerably lower than in Period 2. In general, the steers in Period 3 received less nutrients than in Period 2, the consumption of protein being especially decreased. This was due to the slump in the appetites of the full-feed steers and the consequent reduction in the rations of the steers of the other lots.

As one would naturally expect, there was a decrease in the rate of gains in Period 3, as shown in Table 14, page 588. This decrease was quite marked except in the cases of three steers, Nos. 669, 657, and 663. The decrease in rate of gains was greatest in case of the full-feed lot. In fact, the two-thirds-feed lot made as good gains in this period as the full-feed lot. In this connection it may be noted that there was little difference in the consumption of digestible protein and net energy between these two lots during this period.

Referring to Table 17, page 593, it is seen that in general more total dry substance was required to produce a pound of gain in Period 3 than in Period 2. However, Steers 669, 668, 657, and 663 were exceptions, making slightly more economical gains in this than in the preceding period. Table 18, page 594, shows that the consumption of digestible dry substance per pound of gain was greater in Period 3 than in Period 2. Furthermore, the exceptions noted above are not so noticeable in this case. By reference to Table 19, page 595, it is seen that the economy of the gains, as measured by the consumption of net energy per pound of gain, decreased in Period 3 in every instance except in case of Steer 663. In general, then, it seems safe to say that the efficiency of the ration was decreased in Period 3. This is what one would expect after comparing the feed consumption in Periods 2 and 3. Also the increased condition, especially of the full-feed steers, undoubtedly tended to decrease the rate and economy of gains. Furthermore, it seems probable that the small amount of protein consumed in Period 3 may have adversely affected the rate and economy of gains.

Influence of Change from Hay 1 Part and Corn 5 Parts, to Hay 1 Part, Corn 4 Parts, and Linseed Meal 1 Part.—During the third transitional period the corn of the ration was gradually reduced and old-process linseed meal was gradually introduced into the ration, so that during Period 4 the steers received a ration the same as in Period 3 except that a part of the corn was replaced by linseed meal. There was little or no difference in the actual amounts of hay and of concentrates eaten in Periods 3 and 4 (see Tables 3 and 4). However,

when the feed consumption is computed in terms of 1000 pounds live weight, it is evident that there was a slight reduction in the amount of feed consumed in Period 4, especially in case of the two-thirds- and full-feed lots, owing to the increased weight of the animals (see Table 5). The consumption of digestible dry substance per 1000 pounds live weight in Period 4 was nearly as great as in Period 3. Of course the digestible protein was increased considerably by the addition of linseed meal. In fact, the consumption of protein was almost doubled. The consumption of net energy, as given in Table 9, was also slightly lower in Period 4 in most instances. In general, the consumption of nutrients per 1000 pounds live weight was practically the same in Periods 3 and 4, except in case of the protein, which was almost twice as great in Period 4 as in Period 3 (see Tables 6, 7, and 9).

The average daily gains (Table 14) show that the introduction of linseed meal into the ration affected the rate of gains quite materially. In case of the one-third-feed lot and the two-thirds-feed lot, the gains of all steers increased considerably after the introduction of linseed meal. In the full-feed lot, the gains of three steers increased while the gain of one steer (No. 663) decreased after the addition of linseed meal. In this connection it should be noted that Steer 663, whose gains decreased after the linseed meal was introduced into the ration, went off feed quite badly during this period and was removed from the experiment at the end of the 30th week. Also, the increases in the gains of the other steers of the full-feed lot after the introduction of linseed meal were much greater than those of the two-thirds-feed lot. In fact, the increase in the gains of the full-feed lot after the introduction of the linseed meal was quite marked. In this connection it is well to state again that in Period 4 slightly less total dry substance, slightly less digestible dry substance, and slightly less net energy were consumed than in Period 3. However, almost twice as much protein was consumed in Period 4 as in Period 3. Apparently the addition of protein to the nutrients was responsible for the increased gains. Why the increase in gains should vary with the amount of feed consumed is not explained by these data.

A study of Table 16 shows that in case of the one-third-feed lot, about 54 percent more feed was required to produce a pound of gain in Period 3, when no nitrogenous concentrate was fed, than in Period 4, when linseed meal was substituted for an equal amount of corn. In the two-thirds-feed lot, 57 percent more feed was required to produce a pound of gain in the corn period than in the corn and linseed meal period. In the full-feed lot, 62 percent more feed was required to produce a pound of gain when corn was the sole concentrate than when linseed meal was also used. In this connection it should be remembered that if the same ration had been fed in Periods 3 and 4, we should have expected that more feed would be required in Period

4 as the steers were older and more nearly finished in this period. However, before drawing any definite conclusions from these data, the data of the individual animals should be considered, especially in view of the small number of animals in each lot. It will simplify the study to speak in terms of dry substance per pound of gain rather than in terms of corn, hay, and linseed meal per pound of gain.

Table 17, page 593, shows the individual data pertaining to the amount of dry substance per pound of gain. These data are more easily studied if the amount required to produce a pound of gain in Period 3 is calculated in percent of the amount required to produce a pound of gain in Period 4. Assuming the amount consumed in Period 4 as 100 percent, the amounts consumed by the different steers in Period 3 were as shown in Table 20.

TABLE 20.—DRY SUBSTANCE CONSUMED PER POUND OF GAIN IN PERIOD 3 EXPRESSED IN PERCENT OF THE AMOUNT CONSUMED PER POUND OF GAIN IN PERIOD 4

Steer No.	One-third-feed lot	Steer No.	Two-thirds-feed lot	Steer No.	Full-feed lot
667	155.4	668	189.8	659	168.2
666	260.9	652	125.0	663	92.9
669	123.4	665	200.1	661	267.4
662	131.5	657	123.6	664	192.8
Average	167.8	Average	159.6	Average	180.3

Considering the individual steers of the one-third-feed lot, it is found that the rations of all four steers were more efficient after the addition of the linseed meal. Consequently, it seems safe to conclude that the introduction of linseed meal into the ration of the one-third-feed lot increased the efficiency thereof.

Referring to the data concerning the steers of the two-thirds-feed lot, it is seen that the rations of all steers again were more efficient after the introduction of linseed meal. Taking this into consideration, it seems safe to conclude that the introduction of linseed meal into the ration of the two-thirds-feed lot materially increased the efficiency of the ration.

Considering the steers of the full-feed lot, it is seen that the introduction of the linseed meal increased the efficiency of the ration to a marked degree in cases of Steers 659, 661, and 664. Steer 663 made less economical gains after the introduction of the linseed meal. This was doubtless due to the fact that this steer went off feed and scoured badly during the 28th, 29th, and 30th weeks of the experiment. In fact, at the end of the 30th week it was necessary to remove him from the experiment and put him on another ration. Taking this into consideration, it seems safe to conclude that the introduction of linseed meal into the ration of the full-feed lot caused a marked increase in the economy of the ration.

Referring again to Table 18, page 594, showing the amount of digestible dry substance consumed per pound of gain, and to Table 19, page 595, showing the amount of net energy consumed per pound of gain, it is seen that in the one-third-feed and two-thirds-feed lots all of the steers made more economical gains after the addition of linseed meal. In the case of the full-feed lot, this was also true of Steers 659, 661, and 664, but the gain of Steer 663 was less economical. However, as previously noted, this steer was not in normal condition during this period.

From these results, one concludes that the introduction of linseed meal into the ration caused the gains to be made more economically, as measured by the consumption of digestible dry substance and net energy.

SUMMARY

1. Sixteen two-year-old, choice feeder steers were divided into four lots of four steers each. One lot was given a ration slightly above maintenance; another, an amount of feed equal to the maintenance ration plus one-third of the difference between the maintenance and the full-feed rations; another, an amount equal to the maintenance ration plus two-thirds of the difference between the maintenance and the full-feed rations; and another, as much feed as the steers would eat readily.

2. The experiment lasted for thirty-seven weeks and was divided into five test periods. The first period was five weeks in length, the second, third, and fourth were each six weeks in length, and the fifth was four weeks in length.

3. The feeds used were clover hay, ground corn, and linseed oil meal. The ration of the first test period consisted of clover hay and ground corn in the ratio of 1:1; that of the second, of clover hay and ground corn in the ratio of 1:3; that of the third, of clover hay and ground corn in the ratio of 1:5; and that of the fourth and fifth, of clover hay, ground corn, and linseed oil meal in the ratio of 1:4:1.

4. In Period 1, when the ration consisted of equal parts of clover hay and ground corn, the average daily gains of the different lots and the individual variations were as follows:

Lot	Average	Variations
	lbs.	*lbs.*
Maintenance	1.46	0.34–1.97
One-third-feed	2.08	1.69–2.51
Two-thirds-feed	2.87	2.51–3.37
Full-feed	2.98	2.54–3.40

The consumption of dry substance, digestible dry substance, and net energy per pound of gain by the one-third-, two-thirds-, and full-feed lots was as follows:

Lot	Dry substance		Digestible dry substance		Net energy	
	Average	Variations	Average	Variations	Average	Variations
	lbs.	*lbs.*	*lbs.*	*lbs.*	*therms*	*therms*
One-third-feed	6.61	5.35–8.17	4.36	3.68–5.38	4.12	3.50–5.09
Two-thirds-feed	6.25	5.37–7.21	3.99	3.41–4.63	3.76	3.21–4.34
Full-feed	7.33	6.02–8.71	4.59	3.82–5.40	4.32	3.61–5.06

5. In Period 2, when the ration consisted of 1 part of clover hay to 3 parts of ground corn, the average daily gains of the different lots and the individual variations were as follows:

Lot	Average	Variations
	lbs.	*lbs.*
Maintenance	0.00	–0.12–0.07
One-third-feed	1.64	1.31–1.98
Two-thirds-feed	1.84	1.57–2.24
Full-feed	2.28	1.95–2.62

The consumption of dry substance, digestible dry substance, and net energy per pound of gain by the one-third-, two-thirds-, and full-feed lots was as follows:

Lot	Dry substance		Digestible dry substance		Net energy	
	Average	Variations	Average	Variations	Average	Variations
	lbs.	*lbs.*	*lbs.*	*lbs.*	*therms*	*therms*
One-third-feed	7.95	6.57–10.12	5.71	4.73–7.20	5.90	4.88–7.45
Two-thirds-feed	9.96	7.78–11.85	6.85	5.40–8.09	7.05	5.54–8.33
Full-feed	9.86	8.27–12.06	6.36	5.35–7.24	6.51	5.47–7.40

6. In Period 3, when the ration consisted of 1 part of clover hay and 5 parts of ground corn, the daily gains of the different lots were as follows:

Lot	Average	Variations
	lbs.	*lbs.*
Maintenance	0.04	–0.12–0.14
One-third-feed	1.12	0.55–1.40
Two-thirds-feed	1.48	1.02–1.74
Full-feed	1.50	0.90–2.12

The consumption of dry substance, digestible dry substance and net energy per pound of gain was as follows:

Lot	Dry substance		Digestible dry substance		Net energy	
	Average	Variations	Average	Variations	Average	Variations
	lbs.	*lbs.*	*lbs.*	*lbs.*	*therms*	*therms*
One-third-feed..	10.40	8.05–20.30	7.91	6.10–15.24	8.46	6.53–16.33
Two-thirds-feed	11.08	9.70–16.47	8.15	7.14–11.71	8.72	7.63–12.53
Full-feed.....	12.41	7.64–20.16	8.63	5.66–13.16	9.08	6.04–13.65

7. In Period 4, when the ration consisted of 1 part of clover hay, 4 parts of ground corn, and 1 part of linseed meal, the daily gains were as follows:

Lot	Average	Variations
	lbs.	*lbs.*
Maintenance.....	0.85	0.74–0.95
One-third-feed.....	1.65	1.36–2.17
Two-thirds-feed.....	2.14	1.74–3.07
Full-feed.....	2.45	1.81–2.86

The consumption of dry substance, digestible dry substance, and net energy per pound of gain was as follows:

Lot	Dry substance		Digestible dry substance		Net energy	
	Average	Variations	Average	Variations	Average	Variations
	lbs.	*lbs.*	*lbs.*	*lbs.*	*therms*	*therms*
One-third-feed..	6.81	5.18–7.78	5.24	3.98–6.04	5.53	4.20–6.38
Two-thirds-feed.	7.06	5.11–8.28	5.30	3.83–6.22	5.58	4.04–6.55
Full-feed.....	7.64	6.94–8.22	5.79	5.50–6.50	6.15	5.56–6.87

8. Considering the entire experiment of thirty-seven weeks, the daily gains were as follows:

Lot	Average	Variations
	lbs.	*lbs.*
Maintenance.....	0.70[1]	0.37–1.05[1]
One-third-feed.....	1.32[1]	1.23–1.39[1]
Two-thirds-feed.....	1.79[1]	1.75–1.81[1]
Full-feed.....	2.13	1.98–2.29

[1]This average includes the data for two steers which were upon full feed from the 31st to the 37th week inclusive.

The consumption of dry substance, digestible dry substance, and net energy per pound of gain was as follows:

Lot	Dry substance		Digestible dry substance		Net energy	
	Average	Variations	Average	Variations	Average	Variations
	lbs.	*lbs.*	*lbs.*	*lbs.*	*therms*	*therms*
One-third-feed	9.51[1]	9.17–10.04[1]	6.96[1]	6.73–7.29[1]	7.22[1]	6.97–7.55[1]
Two-thirds-feed	9.40[1]	8.95– 9.64[1]	6.67[1]	6.48–6.86[1]	6.90[1]	6.67–7.10[1]
Full-feed	9.63	8.41–10.47	6.60	5.95–7.23	6.73	6.10–7.48

[1]This average includes the data for two steers which were upon full feed from the 31st to the 37th week inclusive.

CONCLUSIONS

1. Two-year-old steers may be maintained on 8 to 9 pounds of dry substance, 0.39 to 0.44 pound of digestible crude protein, and 6.5 to 6.8 therms of net energy per 1000 pounds live weight.

2. Fattening two-year-old steers may make satisfactory gains over a period of thirty-seven weeks on 14.3 to 22.1 pounds of dry substance, 0.72 to 1.44 pounds of digestible crude protein, and 11.9 to 13.0 therms of net energy per 1000 pounds live weight. Fairly good gains may be made even on less amounts than these.

3. The rate of gains of two-year-old steers depends upon the amount of feed consumed. However, the amount of feed consumed between one-third feed and full feed apparently has no effect upon the economy of gains as measured by the consumption of feed, of total dry substance, of digestible dry substance, and of net energy per pound of gain.

4. When a ration consisting of clover hay and ground corn in equal parts is changed to a ration consisting of one part of clover hay and three parts of corn, the amounts of digestible dry substance and net energy remaining practically unchanged, but the protein being reduced 10 to 12 percent, the rate of gains and the economy of gains are considerably decreased.

5. When a ration consisting of one part of clover hay and three parts of ground corn is changed to one consisting of one part of clover hay and five parts of ground corn, the digestible dry substance, digestible protein, and net energy also being slightly reduced, the rate and economy of gains are decreased.

6. The substitution of one part of linseed meal for one part of corn in a ration of clover hay one part and ground corn five parts materially increases the rate of gains and the economy of gains.

7. Steers which have been kept on a low plane of nutrition (maintenance) for a considerable time make more economical gains when put upon a full-feed ration than steers which have been upon full feed for some time. However, steers receiving more than a maintenance but less than a full-feed ration make no more economical gains when put upon full feed than steers which have already been on full feed.

8. From the results obtained in this investigation, it seems safe to conclude that steers may be maintained or fattened with the ordinary rations of the corn belt on less digestible dry matter, on less digestible protein, and on less net energy than the amounts prescribed by the generally accepted feeding standards.

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